

**FINAL**

Level II Screening Ecological Risk Assessment  
Portland Shipyard, Operable Unit 2  
Swan Island Upland Facility

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## LIST OF ACRONYMS AND ABBREVIATIONS

1x-	One time
5x-	Five times
%	Percent
90UCL	90 <sup>th</sup> percentile Upper Confidence Limit
ACA	Ash Creek Associates
ARL	Acceptable Risk Level
bgs	Below Ground Surface
BW	Body Weight
CA	Contaminated Area
COIs	Contaminants of Interest
COPC	Chemicals of Potential Concern
CPECs	Contaminants of Potential Ecological Concern
CSM	Conceptual Site Model
DEQ	Department of Environmental Quality
EBV	Ecological Benchmark Value
Eco-SSL	Ecological Soil Screening Level
ECSI	Environmental Cleanup Site Information
EPCs	Exposure Point Concentrations
GIS	Geographic Information System
ERA	Ecological Risk Assessment
HHRA	Human Health Risk Assessment
HPAHs	High Molecular Weight Polycyclic Aromatic Hydrocarbons
HR	Home Range
LC50	Median Lethal Concentration
LD50	Median Lethal Dose
LOAEL	Lowest Observed Adverse Effects Level
LPAHs	Low Molecular Weight Polycyclic Aromatic Hydrocarbons
LWG	Lower Willamette Group
MDCs	Maximum Detected Concentrations
MTCA	Model Toxics Control Act
mg/kg	Milligram per kilogram
NOAEL	No-observed-adverse-effects level
OAR	Oregon Administrative Rule
OBP	Oregon Bureau of Planning
OHW	Ordinary High Water Line
ONHP	Oregon Biodiversity Information Center
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
Q	Receptor Designator
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
SCE	Source Control Evaluation
SIUF	Swan Island Upland Facility
SLVs	Screening Level Values
T	Toxicity Ratio

TBT	Tri-n-butyltin
T/E	Threatened and Endangered
TMDP	Technical-Management Decision Point
TQ	Toxicity Quotient
USEPA	Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VCP	Voluntary Cleanup Program
VOCs	Volatile Organic Compounds
WDOE	Washington Department of Ecology

## 1.0 INTRODUCTION

This document presents the Level II Screening Ecological Risk Assessment (ERA) for the Swan Island Upland Facility (SIUF) (ECSI Site No. 271) Operable Unit 2 (OU2), Portland, Oregon. The ERA is being performed as part of a Voluntary Agreement for Remedial Investigation, Source Control Measures, and Feasibility Study for the SIUF between the Port of Portland (Port) and Oregon Department of Environmental Quality (DEQ), dated July 24, 2006.

### 1.1 Purpose and Scope

A draft Level I Scoping ERA was prepared and submitted to DEQ in February 2006 (NewFields 2006). Based on the results of the Level I analysis, it was determined that a Level II Screening ERA was warranted for potential exposure of ecological receptors to riverbank soils. Additional riverbank soil sampling occurred in 2010 to support the risk evaluation and the Source Control Evaluation (SCE) at the facility (Ash Creek Associates [ACA] 2010). A draft Level II ERA based upon the process prescribed by DEQ in the *Guidance for Ecological Risk Assessment: Levels I, II, III, IV* (DEQ 1998 with updates through 2001) was submitted to DEQ in April 2010 (Formation Environmental [Formation] 2010). Comments on the source control document were received from DEQ on August 9, 2010. At the request of DEQ, the Port conducted additional riverbank soil and surface soil sampling at a historical substation and in areas of visible erosion that were identified during site reconnaissance. Sampling summary letter reports and a SCE addendum were provided to DEQ in 2011 (ACA 2011a, 2011b, 2011c). Comments on the draft Level II Screening ERA were discussed with DEQ during a conference call on June 6, 2012 (DEQ 2012). This draft report presents the Level II risk assessment as described in DEQ guidance. Consistent with DEQ discussions in June 2012, the report also includes an expanded Level II exposure and risk analysis and population-level probabilistic analyses for OU2.

The DEQ guidance describes a sequence for conducting ERAs, beginning with Level I Scoping. The purpose of the Level I ERA is to provide a conservative qualitative determination of whether there is reason to believe that ecological receptors and/or exposure pathways are present at OU2. If existing information indicates that site conditions will not result in exposure of ecological receptors, then no further risk analysis is necessary. If hazardous substances and exposure pathways are present, the process proceeds to a Level II Screening analysis to determine if hazardous substances are present at potentially ecotoxic concentrations and, if so, what additional risk analysis may be necessary to make risk management decisions for a facility. This document also presents an expanded Level II analysis and supplemental population-level probabilistic risk evaluations to help support risk management decisions.

In accordance with the Voluntary Agreement, the scope of the Level II ERA at OU2 is limited to the upland areas above the ordinary high water (OHW) mark of the Willamette River.

## 1.2 Facility Location, Description and History

For the purpose of this ERA, the “Facility” consists of OU2, which is part of the SIUF. The SIUF was previously referred to by DEQ as the “Swan Island Portland Ship Yard” and identified by DEQ as Environmental Cleanup Site Information (ECSI) Site 271. OU2 was created as an accommodation to the Port’s desire to lease all or some of the property concerned to a new tenant. Figure 1-1 shows the location of the SIUF and the boundary of OU2. OU2 consists of approximately 24 acres of upland property at the SIUF and is owned by the Port. Prior to 2008, OU2 also included the paved parking area now designated as Operable Unit 4 (OU4). Specific details of site history are discussed in the Draft Supplemental Preliminary Assessment (ACA 2006) and RI/FS work plan (Bridgewater 2000).

The Port acquired Swan Island in 1922. At that time, the main channel of the river was on the easterly side of the island, between the island and what is now Mocks Landing. Following the purchase, the navigation channel was relocated to the west side of the island. Shore areas on the island were excavated to form a new and wider channel to the southwest. The island’s surface elevation was raised with fill from excavation and dredging activities. A causeway was constructed to the southeast to connect the island to the shore, which created Swan Island Lagoon. Swan Island was then developed and served as the municipal airport for Portland from 1931 until it was relocated to Portland International Airport in 1940. The airport was used by private aviation tenants until 1942.

In 1942, the U.S. Maritime Commission entered into an agreement to lease approximately 250 acres of Swan Island from the Port. The Maritime Commission then contracted with Kaiser Company for the construction and operation of a shipbuilding yard on the island. Kaiser operated the shipyard until 1945. From 1945 until 1949, the shipyard was sub-leased by the United States to various tenants. In 1949, the Port purchased the shipyard assets from the United States and subsequently managed the shipyard as a multi-user facility until 1996. In 1996, all shipyard management activities were assumed by Cascade General. The Port sold the shipyard to Cascade General in 2000.

OU2 has been used for relatively low-impact industrial activities throughout its history. A paved runway was present on OU2 during the period of operation of the municipal airport on Swan Island (1931 until 1942). From the 1940s to 1978, OU2 was primarily open land with railroad spurs used for materials receiving and storage. In 1978, the area was used to stage pre-cast concrete structures for construction of the ballast water treatment plant at Operable Unit 1 (OU1). From 1985 until 1990, OU2 was used by the Atlantic Richfield Company to construct modular units for oil processing on Alaska’s North Slope. After 1990, OU2 was used for materials and equipment storage in support of ship repair activities; sand, gravel, and rock storage; for a concrete batch plant; for storage and assembly of pieces of the Freemont Bridge; and for truck and trailer parking.

### 1.3 Current and Future Site Uses

Currently, a portion of OU2 is leased to Daimler Trucks North American LLC (DTNA) for temporary staging of trucks and trailers, and a portion is leased to CEMEX for a concrete batch plant. The remainder of OU2 is vacant. The DTNA Leasehold covers approximately 7 acres at the southeast end of OU2. The CEMEX Leasehold includes approximately 12.1 acres in the central portion of OU2. Vacant areas include 2.7 acres of land along Berth 315 and the strip of land (2.2 acres) between the DTNA/CEMEX Leaseholds and the OHW.

The current and reasonably likely future land use for OU2 and the SIUF is industrial. The SIUF is currently zoned industrial and lies within the City of Portland Industrial Sanctuary and Swan Island Plan District. The SIUF is expected to continue to be used for industrial purposes, consistent with goals and policies stated in the City's Comprehensive Plan (Oregon Bureau of Planning (OBP) 2006).

OU2 is surrounded by similarly developed tracts and no significant upland ecological resources are present within 1 mile of OU2. No change in land use conformation is anticipated for the foreseeable future.

### 1.4 Summary of Investigations

A Baseline Human Health Risk Assessment (HHRA) (ACA 2009a) was completed in September 2009. The HHRA provided a comprehensive summary of the multiple investigations conducted between 2000 and 2008 to support the RI and risk assessment efforts, as well as sampling performed on OU2 prior to the RI in 1998.

The following RI data collection activities and related reports at the OU2 Facility include the following:

- Remedial Investigation/Feasibility Study Work Plan for the Portland Shipyard (Bridgewater 2000);
- Phase IB Work Plan Addendum, Portland Shipyard Remedial Investigation (Bridgewater 2001);
- Phase IB and II Soil and Groundwater Sampling Results, Portland Shipyard Remedial Investigation (Bridgewater 2002);
- Operable Unit 2, Removal Action Report, Swan Island Upland Facility (Bridgewater 2006);
- Former Substation and Berth 305 Sampling Results Addendum, Swan Island Upland Facility (ACA 2007b);
- Swan Island Upland Facility, Operable Unit 2 Supplemental Sampling Results (Port 2007a);
- Memorandum: Storm Water Piping Removal Oversight (ACA 2007a);

- Memorandum: Outfalls, Swan Island Upland Facility – Operable Unit 2 (ACA 2008);
- OU2 Riverbank Soil Sampling and Pipe Abandonment, Swan Island Upland Facility (ACA 2009b);
- Swan Island Upland Facility, Operable Unit 2, Supplemental Groundwater Sampling Results (Port 2007b);
- 2007 Annual Groundwater Monitoring Results, Swan Island Upland Facility, Remedial Investigation (Bridgewater 2008);
- Source Control Evaluation, Operable Unit 2, Swan Island Upland Facility (ACA 2010);
- OU2 Riverbank Soil Sampling, Swan Island Upland Facility (ACA 2011a);
- OU2 Surface Soil Sampling, Swan Island Upland Facility (ACA 2011b);
- Source Control Evaluation (SCE) Addendum, Operable Unit 2, Swan Island Upland Facility (ACA 2011c).

The data collected before 2006 were incorporated into the Level I ERA and the additional data collected since 2006 are considered in this Level II ERA.

## 1.5 Summary of Level I Scoping ERA

A draft Level I Scoping ERA was prepared and submitted to DEQ in February 2006 (NewFields 2006) and is included in Appendix A. In addition, a March 2006 DEQ comment letter (DEQ 2006a) was responded to in a July 2006 Port letter (Port 2006). The letters (and attachments) are also included in Appendix A.

The Level I evaluation concluded that there are limited ecological resources present in the upland areas at OU2. The upland area is either devoid of vegetation in work/paved areas or contains sparse ruderal vegetation. Wildlife is unlikely to feed in these portions of OU2 and ecological exposures would be limited to intermittent and transient presence. There does not appear to be complete exposure pathways for terrestrial plant and animal populations in the upland portion of OU2.

The vegetated riverbank areas may be habitat for small birds and small mammals, and may be visited by other species in transit. Except for the three locations where drain pipes were installed for ARCO, upland areas have not drained to the riverbank. These pipes were capped when ARCO ceased its operations in 1990, and the Port removed the pipes in 2006 (ACA 2007a). Therefore, exposure of ecological receptors to site-specific contaminants on the riverbank or shoreline areas is unlikely. However, because complete exposure pathways are possible in the riverbank areas, it was determined by DEQ that a Level II screening analysis would be necessary.

Overall, based on the Level I ERA, it was determined that potential exposure pathways exist for ecological receptors that could contact contaminants of interest (COIs) in surface soils in riverbank areas as a result of potential transport from pipelines discharging on the riverbank. Potential ecological receptors evaluated in the Level II evaluation are plants and invertebrates in the riverbank area and small birds and mammals that may visit that area.

## **1.6 Document Organization**

Section 2 includes the description of ecological site conditions. Section 3 presents the methodology and results of the Level II Screening analysis, including identification of contaminants of potential ecological concern (CPECs) and a preliminary conceptual site model (CSM). Section 4 outlines the methodology and results of an expanded Level II analysis. Section 5 presents supplemental population-level probabilistic risk evaluation methodology and results. Technical Management Decision Points (TMDPs) and overall conclusions are summarized in Section 6. References are provided in Section 7.

## 2.0 ECOLOGICAL SITE DESCRIPTION

A Facility visit was conducted by the project lead ecological risk assessor on October 31, 2005. The Level I Scoping ERA (NewFields 2006) presented an ecological site description based on an OU2 visit, aerial photographs, and general Facility knowledge. Site conditions have not changed appreciably since that time, and the ecological site description is presented below. Refer to the Level I Scoping evaluation in Appendix A for photographs from site visits.

### 2.1 Site Description and Site-Specific Ecological Receptors

The portions of OU2 that are northeast (i.e., inland) of the Willamette River bank are largely devoid of vegetation and are generally composed of asphalt-covered parking lot or gravel-covered work areas with concrete slabs. Vegetation on most of the property is strictly ruderal, with sparse vegetation consisting of opportunistic or weedy annual species, but more commonly containing no vegetation at all (Figure 1-1). The surface soil conditions and use in these areas prevent more long-lived plant species from establishing and creating an early successional native habitat type. The unpaved portions of OU2 do not, and will not, provide suitable habitat for ecological receptors because of former, current, and reasonably likely future uses of the property (i.e., truck and trailer parking and aggregate processing).

The riverbank and beach conditions at OU2 are summarized below but are described fully in the SCE and SCE addendum (ACA 2010, 2011c). A visual reconnaissance of the OU2 riverbank was completed in 2010 to identify geomorphic features, vegetation, and structures. The riverbank at OU2 is composed of fill material with rock, concrete debris and rip-rap. The surface condition of the riverbank is characterized by dense vegetation above the approximate OHW. Below the OHW, the bank generally consists of rip rap with occasional sandy beaches. The visual reconnaissance in 2010 identified 17 surface features along the riverbank, including six structures (3 outfalls, 1 historical substation platform, 1 manway, and 1 aggregate conveyor), two areas of historical bank disturbance that are now densely vegetated, three areas of bare ground, and six visible erosion scarps. The erosion scarps are linear features running parallel to the riverbank that are located at or above the transition from rip rap to vegetated riverbank. Other than these features, the riverbank area is densely vegetated with ground cover of grasses and shrubs, including introduced species such as Himalayan blackberry. A variety of willow species (e.g., Pacific, Columbia River, and Piper's Willow) and black cottonwood saplings have become established on the beach. The vegetated area on the river bank (approximately 3-5 acres) is narrow (approximately 45-80 feet wide) and is disconnected from riparian upland areas.

Riverbank sampling locations in the Level II assessment include samples collected between OHW and the ordinary low water line (OLWL). This is based on direction from DEQ to: (1) sample these locations; and (2) to use these data in the Level II characterization (DEQ 2006a & April 20, 2006 meeting as cited in DEQ 2006b).

During the site visit, no receptors other than waterfowl and other birds associated with the river were observed at OU2. However, it is possible that songbirds may utilize the shrub areas during other parts of the year.

The Willamette River near OU2 provides habitat for aquatic and semi-aquatic species. The river is identified as a sensitive environment in Oregon Administrative Rule (OAR) 340-122-0115. There are no wetlands or permanent water bodies on OU2.

During the Portland Harbor RI/FS, the Lower Willamette Group (LWG) collected crayfish, largescale sucker, sculpin, peamouth, and small mouth bass within one mile of OU2, but no biota sampling was attempted near the shore of OU2. The LWG collected sediment samples offshore of OU2 and a beach sediment sample from the beaches adjacent to OU2. The resulting data is being used in the Portland Harbor RI/FS process, but are not used in this report since these sampling locations are not in OU2.

### 2.1.1 Threatened and Endangered Species

A listing of threatened and endangered (T/E) species potentially present within a two-mile radius of OU2 was provided by the Oregon Biodiversity Information Center (OBIC). The list includes historical presence of federal and state-listed T/E species. The Level I ERA in Appendix A summarizes the species listed by the OBIC. A copy of the letter from the ONHP identifying the species is also included in Appendix A.

Yellow-billed cuckoo is identified as a candidate T/E species in the vicinity. In the ONHP records, the last known observation of the yellow-billed cuckoo is along the Columbia River in 1985. According to the U.S. Fish and Wildlife Service (USFWS) species profile (USFWS 2010), Oregon counties in which the yellow-billed cuckoo is currently known to occur include: Harney, Deschutes, and Malheur. It is not listed as currently occurring in Multnomah County. Thus, no federally-listed T/E upland wildlife species are assumed to occur at OU2.

## 2.2 Observed Impacts

Ecological resources (habitat or food sources) are extremely limited within OU2, restricted to the narrow riverbank area. No ecotoxicological impacts on ecological receptors were observed at OU2.

### 2.3 Other Ecologically Important Species/Habitats

Based on the Facility visit, historical information, ONHP data, and general Facility knowledge, there are no rare or ecologically unusual habitats or species at the Facility.

### 3.0 LEVEL II SCREENING ANALYSIS

#### 3.1 Methods for Level II Screening

The ecotoxicological risk screen was conducted according to DEQ guidance for Level II Screening ERA (DEQ 2001), with additional modifications based on discussion with DEQ (DEQ 2012). DEQ guidance specifies several tasks when the Level II analysis is conducted independently. However, many of the tasks and much of the background information cited in the Level II guidance were addressed in the Level I evaluation (i.e., conduct site survey, provide site description, identify ecological receptors, and identify complete exposure pathways) and are summarized in the previous section. Therefore, the analysis presented below focuses on the tasks that relate directly to conducting the Level II screen, including:

- evaluate data sufficiency (Task 1 of the guidance);
- identify candidate assessment endpoints (Task 6);
- identify known ecological effects (Task 7);
- calculate COI concentrations (Task 8);
- identify contaminants of potential ecological concern (CPECs) (Task 9); and
- develop preliminary conceptual site model (CSM) (Task 10).

Expanded Level II and supplemental population-level probabilistic analyses were performed to support this ERA and those analyses are discussed further in Sections 5.0 and 6.0.

##### 3.1.1 Data Available for Screening

There has been considerable sampling to support the RI; refer to Section 1.4 (Summary of Investigations). As summarized in the HHRA for the Facility (ACA 2009a), the RI for the Facility included chemical analysis of up to 97 soil samples and 14 groundwater samples. Additionally, 47 soil samples were later collected in 2006, 2008, and 2011 to support the SCE and SCE addendum (ACA 2010, 2011c). These data are of sufficient quality for use in a risk assessment.

This Level II ERA focuses specifically on surface soil data collected from the riverbank area. Riverbank sampling locations are shown on Figure 1-1 and include: PS-S-01-01/Boring 1 (discrete sample), RB-1 through RB-7 (3 discrete samples and 1 composite sample at each location), and RB-8 through RB-15 (2 discrete samples at each location), and historical Substation A (2 composite samples).

Refer to ACA (2010, 2011a, 2011b) for a description river bank sampling. PS-S-01-01/Boring 1 was collected as a discrete sample. The sampling at RB-1 through RB-7 locations consisted of

three discrete samples down the riverbank at each location and one composite sample combined from the discrete samples. The sampling at RB-8 through RB-15 locations consisted of two discrete samples along the riverbank feature at each location (e.g., one on top of the erosion scarp at this point on the riverbank, and one downslope on the face of the erosion scarp). At historical Substation A, two composite samples were created from 4 discrete samples within and 4 discrete samples downslope from the footprint of the feature (the discrete samples were not submitted for analysis). Because this historical substation area was the target of focused sampling, data from this area were evaluated separately throughout this assessment.

Refer to Appendix B of this document for analytical results from all riverbank area surface soil samples. Appendices C and E of this document provide a summary of soil sample results, including the depth range of collected samples, detection frequency, minimum and maximum non-detected and detected concentrations for the riverbank (Appendix C) and historical Substation A (Appendix E).

As identified in the HHRA, the COIs include petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), phthalates, tri-n-butyltin (TBT) and metals. Although volatile organic compounds (VOCs) were evaluated as COIs in the HHRA based on presence in groundwater, only two VOCs were identified as chemicals of potential concern (COPCs) in water (vinyl chloride and chloroform), and neither of those were detected in soil. Based on the lack of VOC detections in soil, and a lack of a complete exposure pathway for ecological receptors to encounter VOCs in surface soils of the riverbank, VOCs will not be considered as COIs in this Level II Screening ERA.

Riverbank and Substation A samples were analyzed for a range of COIs including petroleum hydrocarbons, PAHs, PCBs (Aroclors), phthalates, butyltins, and metals (Appendix B). The following list identifies which locations were analyzed for each group of COIs:

- **Petroleum hydrocarbons:** PS-S-01-01/Boring 1 (discrete), RB-1 through RB-7 (composites), Substation A (composites);
- **PAHs:** RB-1 through RB-3 (composites and discretely), RB-4 through RB-7 (composites), RB-8 through RB-15 (discretely);
- **PCBs (Aroclors):** PS-S-01-01/Boring 1 (discrete), RB-1 through RB-7 (composites), RB-8 through RB-15 (discretely), Substation A (composites);
- **Phthalates:** RB-4 through RB-6 (composites);
- **Butyltins:** RB-8 (discretely), RB-10 (discretely), RB-13 (discretely), RB-11 (discretely), RB-4 through RB-6 (composites and discretely; TBT only);
- **Metals:** PS-S-01-01/Boring 1 (discrete), RB-1 through RB-7 (composites), RB-4 through RB-7 (discretely; lead only), RB-8 through RB-15 (discretely);

### 3.1.2 Candidate Assessment Endpoints

According to DEQ guidance (2001), assessment endpoints are "...an explicit expression of a value deemed important to protect, operationally defined by an entity (hereafter, "endpoint receptor") and one or more of that entity's measurable attributes..." Assessment endpoints serve to focus the ERA on species and measures that are directly relevant to risk management decisions for OU2. The assessment endpoints generally represent species or functional groups that are important to ecological function at a site, or rare species that have great ecological, aesthetic, or cultural value.

Assessment endpoints for a screening level assessment (e.g., Level II screening) are typically not as specific as those identified for baseline risk assessments where specific measures or data analysis methods are needed to make decisions. In addition, no T/E or other rare species are known to use the Facility. For the DEQ Level II analysis, screening level values (SLVs) for soils have been identified for general groups of organisms including plants, invertebrates, birds, and mammals. Therefore, the following candidate assessment endpoints were identified:

- Survival, growth, and reproduction of terrestrial plants;
- Survival, growth, and reproduction of terrestrial invertebrates;
- Survival, growth, and reproduction of terrestrial-feeding birds; and
- Survival, growth, and reproduction of terrestrial-feeding mammals.

### 3.1.3 Calculating COI Concentrations

Because wildlife receptors do not experience their environment on a "point" basis, environmental data for each COI need to be converted to an estimate of concentration over a habitat exposure area (DEQ 2001). Exposure-point concentrations (EPCs) are concentrations of COIs that represent a reasonable maximum exposure based on the media characteristics and site-specific receptors. The Level II guidance specifies that screening level EPCs can be based on (1) site maximum detected concentrations (MDCs) for immobile or nearly immobile receptors (i.e., plants and soil invertebrates), or (2) 90%-upper confidence limits (90UCL) of the mean concentrations for more mobile wildlife receptors (i.e., birds, mammals) (DEQ 2001).

EPCs of COIs for soil were calculated using data from riverbank locations to estimate reasonable maximum exposure for wildlife potentially visiting riverbank areas from adjacent locations. This approach assumes that wildlife receptors could utilize all areas of the riverbank; overall, riverbank habitat quality is considered low throughout. Soil samples with an upper depth less than 3 feet below ground surface (bgs) were included in the calculations, to adequately account for both surface soil exposure and exposure to potential burrowing animals.

For use in determining an EPC based on MDC, all available sample results (including composite samples and discrete samples) were included in the determination. The 90UCL-based EPCs

were calculated separately for results from composite and discrete samples, and the results evaluated separately. This procedure prevents different kinds of samples from being combined in the 90UCL calculation. Results from the historical Substation A were not included in the 90UCL calculations, and instead evaluated independently from other riverbank samples.

The U.S. Environmental Protection Agency (USEPA) ProUCL computer program (USEPA 2010, 2011) was used to obtain data distribution evaluations and to calculate the 90UCLs for COIs that exceeded Level II bird and mammal screening criteria based on MDCs. In accordance with ProUCL guidance, each data set was first tested using the ProUCL software to determine the data distribution, and the appropriate 90UCL estimation method was chosen based on the best distribution fit and recommendations provided by ProUCL. In ProUCL, recommendations are provided for 95<sup>th</sup> percentile Upper Confidence Limit (95UCL) calculations only. 95UCL calculations were performed and these recommendations were applied to 90UCL evaluations. Appendix D presents output information from ProUCL 90UCL calculations, amended with notes regarding recommended values from 95UCL calculations. DEQ guidance (DEQ 2001) suggests that non-detects should be included with values of one-half their detection limits. However, the latest ProUCL package (version 4.1.01) includes computation methods (e.g., Kaplan-Meier) that can be used for datasets with non-detect values and so this methodology was used in 90UCL calculations.

### 3.1.4 Frequency of Detection and Background Analysis

COIs were screened on the basis of detection frequency and comparison to regional background levels before being compared to toxicity SLVs, as outlined in Task 9 of the Level II guidance (DEQ 2001). COIs detected in less than 5% of the samples were excluded as CPECs on the basis of infrequent detection (DEQ 2001). Because there were only 2 samples at historical Substation A, detection frequency was not incorporated into the screening evaluation for that sub-area. The MDCs for metals in soils were compared to regional background concentrations, as presented in the DEQ Toxicology Workgroup Memorandum (DEQ 2002) and summarized on Table 3-1. If the MDC for a COI was less than the background value, then the COI was excluded as a CPEC (DEQ 2001).

### 3.1.5 Comparisons to Screening Level Values (SLVs)

CPECs are identified by comparing COI concentrations to DEQ-approved Level II SLVs, and calculating the toxicity ratio (T) of the EPC (MDC or 90UCL) of each of the COIs to Level II approved SLVs (DEQ 2001). The guidance indicates two potential levels of analysis for soil COIs. For T/E species, the toxicity ratio is compared to the “receptor designator” (Q) value of 1 (i.e., if the riverbank soil concentration exceeds the approved SLV, the constituent is identified as a CPEC). For non-protected species, T is compared to a Q value of 5 (i.e., if the riverbank soil concentration exceeds five times [5x-] the SLV, the constituent is identified as a CPEC).

For completeness, both levels of results are presented. However, CPECs for OU2 are identified based on Q=5 because no T/E species are present or expected at the site. In addition, potential risk to a receptor from multiple COIs simultaneously within a given medium is addressed by comparing T of an individual COI to the sum of T for all COIs. If there is only one SLV available for COIs for a receptor, then it is not appropriate to calculate risk from multiple COIs.

If site concentrations are less than 5x-SLVs, no adverse effects are expected and no further analysis is required because risk is assumed to be negligible. It should be noted that the SLVs are based on intensive use of a site by receptors. Because OU2 is industrialized, and will remain so, ecological receptors are unlikely to utilize the site at levels represented in the SLVs. Therefore, concentrations that exceed the SLV do not necessarily represent unacceptable risk, but indicate that additional evaluation of site conditions may be necessary to support risk management decisions.

In June 2012 DEQ requested the use of SLVs different from those listed in the Level II Guidance (DEQ 2012). DEQ requested the following: 1) USEPA's Ecological Soil Screening Level (EcoSSL) values for metals, low molecular weight PAHs (LPAHs), and high molecular weight PAHs (HPAHs) (USEPA 2005a), 2) USEPA Region 5 Resource Conservation and Recovery Act (RCRA) screening levels for phthalates (USEPA 2001), 3) bioaccumulation-based screening levels from Washington State Department of Ecology (WDOE) Model Toxics Control Act (MTCA) (WDOE 2012) and Oak Ridge National Laboratory (ORNL) (Efroymson et al. 1997) sources for PCBs, and 4) WDOE MTCA screening levels for petroleum hydrocarbons (gasoline range organics, diesel range organics) (WDOE 2012).

Table 3-1 provides a summary of the SLVs and sources including: "Oregon DEQ Level II SLVs", "Oregon DEQ-Requested Alternative Screening Levels" (which outlines alternative values discussed above), and "Oregon DEQ-Approved Level II SLVs" (a summary of SLVs based first on DEQ-requested alternative values if available, and secondly on original DEQ Level II SLVs).

### **3.2 Level II Screening Results and Identification of Contaminants of Potential Ecological Concern (CPECs)**

CPEC identification followed Task 9 of the DEQ guidance (DEQ 2001), including consideration of detection frequency, background comparison, cumulative risk from multiple COIs, bioaccumulative toxins, and availability of SLVs. Appendix C presents results of riverbank soil screening based on MDCs for plant, invertebrate, bird, and mammal receptors. For each COI, the tables show a detailed data summary, the MDC, SLVs, and results of the data comparison. Appendix D presents results of riverbank soil screening based on 90UCLs for bird and mammal receptors. Appendix E presents results of soil screening for the historical Substation A sub-area based on MDCs for plant, invertebrate, bird, and mammal receptors.

### 3.2.1 Frequency of Detection and Background Analysis

For riverbank soils at the Facility, MDCs of antimony, chromium, nickel, selenium, and silver were less than regional background concentrations and these analytes are excluded as CPECs (Appendix C), in accordance with Task 9 of DEQ guidance (DEQ 2001). It should be noted that the chromium background level exceeds the SLVs, indicating that this SLV is probably too conservative for use in the Portland area. Facility concentrations of chromium are below the background level and so this COI is not considered a CPEC. MDCs of arsenic, cadmium, copper, lead, and zinc exceeded regional background concentrations (Appendix C). Mercury was not detected in soil samples at a detection limit of 0.1 milligrams/kilogram (mg/kg), which is greater than the background level of 0.07 mg/kg.

Sixteen COIs were excluded as CPECs in riverbank soils because they were not detected and either 1) don't have SLVs; or 2) have a maximum detection limit that doesn't exceed the SLV. No analytes were excluded as CPECs based on frequency detection analysis where detects or detection levels exceeded SLVs.

Frequency of detection and background levels were not incorporated into the Level II screening evaluation for the historical Substation A area, since the two soil samples collected there were evaluated specifically for PCBs.

### 3.2.2 Screening Analysis

#### ***Identification of Candidate CPECs – Historical Substation A Soils***

Appendix E presents soil MDCs for COIs evaluated at the historical Substation A area (PCBs and petroleum hydrocarbons), with comparisons to available SLVs for plants, invertebrates, birds, and mammals. All MDCs for COIs at the historical Substation A were below SLVs (or SLVs were lacking) for all receptors. Overall, the maximum risk ratio calculated for COIs compared to SLVs at the Substation A area is 0.067, which is well below the applicable benchmark of 5.

For birds and mammals, T calculation based on multiple COIs exceeded the threshold. However, calculations of risk ratios for this area are largely based on non-detected concentrations (i.e., eight of the twelve COIs were not detected). In addition, calculations of risk from multiple COIs is influenced by the number of COIs with SLVs (i.e., the contribution from each COI is greater in cases with a reduced COI/SLV list). In addition, the evaluation is influenced by the fact that the Aroclor 1254 SLV was applied to the other Aroclors that were evaluated, but lacked SLVs.

As a result of this Level II screening evaluation, PCBs and petroleum hydrocarbons at the historical Substation A area are deemed not to pose risk to ecological receptors and this sub-area will not be discussed further in this document.

### ***Identification of Candidate CPECs – Riverbank soils***

Appendix C presents riverbank soil MDCs, with comparisons to available SLVs for plants, invertebrates, birds, and mammals. COIs for which the MDC exceeded at least one SLV at the Q=5 level, or are identified as a result of potential risk to a receptor from multiple COIs simultaneously within a given medium, are considered “candidate CPECs” that are subject to further analysis, including calculation of 90UCLs, and comparison to appropriate risk ratios. The Facility does not have suitable habitat for T/E species and so a risk ratio of 5 corresponding to non-T/E species is the applicable benchmark for identifying CPECs (DEQ 2001). For riverbank soils in OU2, four candidate CPECs (copper, lead, zinc, and sum of HPAHs) were identified<sup>1</sup>. These candidate CPECs are discussed further in subsequent sections.

### ***Comparison of MDCs to SLVs for Non-Wildlife Receptors – Riverbank Soils***

Refer to Appendix C for the results of screens for plants and soil invertebrates (i.e., non-wildlife receptors) based on comparisons of the MDCs to SLVs. Since no T/E species are potentially present, a risk ratio of 5 corresponding to non-T/E species is the applicable benchmark for identifying CPECs (i.e., the MDC is greater than 5x-SLV) (DEQ 2001). Table 3-2 summarizes results of the soil toxicity screens for COIs for which the MDC exceeded at least one plant or invertebrate SLV with a risk ratio greater than 5. Zinc and copper were both identified as CPECs for plants and invertebrates (Table 3-2). Potential risks to plants and invertebrates from copper and zinc are further discussed in Section 4.0.

### ***Comparison of 90UCLs to SLVs for Wildlife Receptors – Riverbank Soils***

For bird and mammal receptors (i.e., wildlife receptors), EPCs based on 90UCLs were calculated for candidate CPECs; calculations were performed separately for discrete and composite samples. Refer to Appendix D for the results of screens based on comparisons of the calculated 90UCLs to SLVs. Since no T/E species are potentially present, a risk ratio of 5 corresponding to non-T/E species is the applicable benchmark for identifying CPECs (i.e., the 90UCL is greater than 5x-SLV) (DEQ 2001). Table 3-2 summarizes results of the soil toxicity screens for COIs for which either 90UCL (composite- or discrete-based) exceeded at least one bird or mammal SLV with a risk ratio greater than 5.

For birds, copper, lead, and zinc were identified as CPECs (both composite-based 90UCLs and discrete-based 90UCLs exceeded 5x-SLV). For mammals, copper and zinc were also identified as CPECs (based on either composite- or discrete-based 90UCLs exceeding 5x-SLV, not both)

<sup>1</sup> As noted in Section 3.2.1, Facility concentrations of chromium are below the background level and so chromium is not considered a CPEC.

(Appendix D and Table 3-2). The 90UCL for HPAHs did not exceed the 5x-SLV level and so adverse effects to birds or mammals are not expected from HPAHs in riverbank soils. Additional evaluation of the potential risks to birds and mammals from metals are further discussed in Sections 4.0 (expanded Level II analyses) and 5.0 (population-level probabilistic analyses), and overall conclusions are presented in Section 6.0.

## 4.0 EXPANDED LEVEL II ASSESSMENT

An objective of the Level II Screening is to determine whether additional ecological risk analysis is necessary to support risk management decisions for a site. Results of the Level II screening evaluation identified some metals that exceeded SLVs. Copper (plants, invertebrates, birds, mammals), lead (birds), and zinc (plants, invertebrates, birds, mammals) were identified as CPECs based on screening analyses using SLVs (Table 3-2). SLVs are intended as screening-level estimates of soil concentrations below which no adverse impacts are expected to ecological receptors under any exposure conditions. However, they are not meant as cleanup values and exceedance of the SLVs does not necessarily indicate unacceptable ecotoxicological risk, nor should they be used as cleanup criteria (DEQ 2001). EcoSSLs were developed in a similar context (USEPA 2005a).

Based on discussions with DEQ, additional risk analysis is included in this Level II ERA to provide additional context for the decisions to be addressed in TMDP 3 and TMDP 4 (discussed in Section 6.0). Specifically the goal of the Level II ERA is to determine whether a Level III ERA is necessary to support a risk management decision for OU2. Expanded Level II assessments for plants, invertebrates and wildlife are presented in the following sub-sections. For wildlife, exposure and risk calculations were conducted for birds, using the American robin as a representative species. Based on surveys of toxicity reference values presented in the EPA Eco SSL documents, birds are generally more sensitive than mammals to the metals that are evaluated in this report. As a result of this greater sensitivity and the habitat and environment at OU2, risk management decisions made based on protection of birds would be protective of mammals.

### 4.1 Expanded Level II Assessment – Plants/Invertebrates

Figure 4-1 shows detected zinc soil concentrations at each of the riverbank locations compared to SLVs and 5x-SLVs for plants and invertebrates. Zinc concentrations exceeded the 5x-SLV for plants (800 mg/kg) at one sampling location with the maximum sitewide concentration of zinc (835 mg/kg). However, overall zinc concentrations and qualitative observations during site visits do not indicate phytotoxicity along the riverbank. Zinc concentrations exceeded the 5x-SLV for invertebrates (600 mg/kg) at two locations along the riverbank. These results suggest that invertebrates at these locations could experience zinc exposures that exceed screening levels. Field observations associated with the Level I and Level II analysis did not reveal obvious patterns of phytotoxicity. Given the effects of the physical disturbance and the ruderal/invasive vegetation on natural ecological function, it is unlikely that ecological impacts from phytotoxicity could be identified through field data collection.

Figure 4-2 shows detected copper soil concentrations at each of the riverbank locations compared to SLVs and 5x-SLVs for plants (350 mg/kg) and invertebrates (400 mg/kg). Copper concentration exceeded the 5x-SLV for plants and invertebrates at 2 sampling locations along the riverbank. Based on this limited distribution, it seems unlikely that copper toxicity is limiting the plant and invertebrate communities at OU2.

## 4.2 Expanded Level II Assessment - Birds

Screening results for birds are presented in Table 3-2 and Appendix D. Zinc 90UCL concentrations for both composite and discrete samples exceed the 5x-SLV of 230 mg/kg for birds with a risk ratio ranging from 6.4 to 11.7. Copper 90UCL concentrations exceed the 5x-SLV of 140 mg/kg for birds with a risk ratio ranging from 6.1 to 18.9. Lead 90UCL concentrations exceed the 5x-SLV of 55 mg/kg for birds with a risk ratio ranging from 5.2 to 7.8.

Based on exceedances by concentrations of these CPECs in both discrete and composite soil samples, additional risk analysis for birds was conducted. This expanded Level II analysis focuses on estimating exposure to copper, lead and zinc for bird receptors and expands on the Level II screening by:

1. Identifying a representative bird receptor species with an omnivorous (plant and invertebrate) diet (American robin);
2. Replacing the simple comparison of site soil concentrations to SLVs with an estimation of daily intake of each chemical by birds through ingestion of prey and soils; and
3. Comparing copper, lead, and zinc intake with a range of ecological benchmark values (EBVs) instead of a single SLV.

These steps are more consistent with the exposure assessment and risk characterization components of a baseline risk assessment and are intended to provide risk managers with additional information to support risk management decisions for copper, lead, and zinc in OU2 soils. The following sections provide a summary of the expanded Level II analysis for birds.

### 4.2.1 Representative Bird Receptor

The American robin (*Turdus migratorius*) was identified as the representative receptor for terrestrial-feeding birds because of its small home range and omnivorous diet, and because it was the basis for the DEQ SLVs for exposure of birds to metals in soils. Small birds, such as American robins, are sensitive to metals and represent the potentially most affected receptors. Use of birds to represent ecological risk at the Facility appears to be protective of mammalian wildlife, because birds are generally more sensitive to the CPECs than mammals. American

robins have relatively small home ranges, and individuals could spend substantial amounts of their time along a riverbank area, feeding on both vegetation and invertebrates that could contact affected soils. Robins and similar birds are also food sources for avian and mammalian predators. Such predators are unlikely to be affected by contaminated soils at the Facility since most metals do not biomagnify in terrestrial food webs. However, adverse effects on robins or similar species could affect the abundance or quality of food resources for predators. Modeling food chain exposure to this receptor is a conservative approach that provides an estimate of exposure for the most limiting receptors at the Facility relative to other terrestrial receptors. Therefore, the American robin is a good representative for assessing potential risk to resident, terrestrial-feeding birds at the Facility. Because of the higher potential rates of uptake of metals in invertebrates compared to plants, this analysis assumes a 100% invertebrate diet in order to conduct a conservative evaluation.

#### 4.2.2 Exposure Estimation Methodology

The additional risk analysis was based on standard methods for estimating exposure from food ingestion and incidental ingestion of soils (USEPA 2005a, 1993). Refer to Table 4-1 for a summary of parameters, exposure equations, and sources of data used in the estimation of intakes. Standard dietary intake equations were used to estimate the amount of copper, lead, and zinc that an avian receptor could obtain from ingestion of insect tissue. As directed by DEQ (2012), the overall food intake rate is from WDOE (2012). Other parameters are from the Wildlife Exposure Factors Handbook (USEPA 1993) and Attachment 4-1 of EcoSSL guidance (USEPA 2005a). Since no site-specific data on biological tissue were available, CPEC concentrations in food were estimated using empirically derived uptake relationships from ecotoxicological literature (i.e., Bechtel-Jacobs 1998 and Sample et al. 1999 as recommended in USEPA 2005a). In addition to the ingestion of CPECs accumulated in food items, robins may also be exposed to CPECs through the inadvertent ingestion of surface soil while foraging. Although wildlife receptors may also be exposed to CPECs through the ingestion of surface water, there is no surface water available on the Facility and this exposure pathway was considered incomplete for OU2.

The assimilation efficiency or bioavailability of zinc and copper in ingested soils or biota was assumed to be 100%. This is a conservative estimate since the bioavailability of most metals is less, especially directly from incidentally ingested soils or soils in gut content of prey items. Bioavailability of lead in soils was assumed to be 50%; lead bioavailability from ingested food was assumed to be 100%. These assumptions are conservative in that actual lead bioavailability can be much lower, especially from inorganic forms of lead ore or mill tailings (Ruby et al. 1992), and lead iron oxides that tend to form in soils from soluble forms of lead (Suedel et al. 2006, Schoof 2003). Lead carbonates and organic forms have higher bioavailability (80%) (Suedel et al. 2006, Schoof 2003). Calculation of total intake also assumes that all animals in the subpopulation being assessed obtain 100% of exposure from areas under evaluation (i.e., area use factor equal to 100%).

### 4.2.3 Ecological Benchmark Values (EBVs)

In the context of this assessment, EBVs are exposure rates that are associated with levels of toxicological effects. The exposure rates are expressed as mg of CPEC ingested per Kg body weight, per day (mg/Kg BW/day). As a result, EBVs can be directly compared to the exposure rates estimated using methods described above.

The analysis in this report includes a range of EBVs, representing a range of lethal/sub-lethal toxicological effects and survival, obtained from widely used and accepted toxicological literature sources, consistent with the assumptions outlined in the DEQ guidance (DEQ 2001), and additional direction from DEQ (DEQ 2012). Refer to Table 4-2 for the EBVs that were used in the expanded Level II risk estimation.

In general, mortality-based no-observed-adverse-effects levels (NOAELs) indicate levels at or below which no mortality is expected. Mortality-based lowest-observed-adverse-effect-levels (LOAELs) indicate the lowest test dose at which statistically significant mortality was observed.

In DEQ's probabilistic risk assessment process (Level III in DEQ 2001), EBVs for receptor populations are defined as the median lethal dose or concentration (LD50 or LC50), i.e., based on a lethality endpoint and corresponds to exposures in which 50% of test animals survived. If a LD50 or LC50 is not available for endpoint species considered in the risk assessment, the EBV may be derived from other toxicological endpoints for those receptors (adjusted with uncertainty factors as appropriate), and based, to the extent practicable, on studies whose routes of exposure and duration of exposure are commensurate with the expected routes and duration of exposure for endpoint species considered in the risk assessment (DEQ 2001). DEQ provides guidance in this regard, but they do not provide the LC50 values. Because a Level III probabilistic analysis is used in Section 5, mortality-based endpoints are included in Table 4-2 and the exposure analysis.

Satisfactory LD50 or LC50 EBVs were not available for the CPECs, primarily because of exposure routes and study designs in which lethality measure were derived. Although it is not directly comparable to an LC50, one can infer that if the LOAEL is generally based on less than 50% mortality, then it is likely less than an LC50, if one were available. Exceptions to this assumption are possible, so the results should be interpreted using the data from the toxicological studies on which the LOAEL is based. Calculated EBVs for copper, lead and zinc are included in Appendix G.

### 4.2.4 Expanded Level II Analysis Results - Birds

Results of the exposure calculation and comparison to the EBVs are shown in Table 4-3. Results based on both the discrete- and composite-based 90UCLs are presented. In addition, an estimate of exposure from regional background levels was also calculated for comparison

purposes. A toxicity quotient (TQ) was calculated as the ratio between the estimated exposure and the EBV (DEQ 2001):

$$\text{Toxicity quotient (TQ)} = \text{exposure estimate/EBV}$$

DEQ does not have specific guidance for interpreting the results of deterministic exposure analyses such as that shown for the 'expanded' Level II analysis. In most ecological risk assessment contexts, NOAEL-based TQs equal to or less than 1.0 indicate no adverse effects are expected (i.e., *de minimis* risk) and no further risk analysis is necessary to support site risk management decisions (see for example, USEPA 1997). NOAEL HQs greater than 1 do not necessarily indicate unacceptable risk, but that additional risk analysis may be necessary to support risk management decisions. LOAEL TQs greater than 1 also may not necessarily equate to unacceptable risk, but indicate that sensitive individuals in a population may be affected. At exposures increasingly greater than the LOAEL, a greater number of individuals could be affected, and if exposures are high enough, or widespread enough, adverse impacts on populations could occur.

Table 4-3 shows TQs calculated for each EBV based on the exposure estimates calculated from discrete and composite samples, and for exposure calculated using background soil concentrations for each of the metals. Important aspects of the TQ results are:

- TQs exceeding 1.0 are observed for NOAELs for sublethal- and mortality-based endpoints for each of the chemicals, for composite and discrete sample groups.
- TQs exceeding 1.0 for sublethal NOAELs are also observed for background metal concentrations.
- For zinc, LOAEL-based TQs exceeded 1.0 for discrete and composite samples. No LOAEL-based TQ exceeded 1.8. No LOAEL-based TEQs exceeded 1.0 for background concentrations.
- For lead, no LOAEL-based TQs exceeded 1.0 for composite or discrete samples, or for background concentrations.
- For copper, no LOAEL-based TQs exceeded 1.0 for composite samples or background concentrations. LOAEL-based TQs exceeded 1.0 for discrete samples, with a maximum of 2.5.

Because at least one NOAEL-based TQ exceeded 1.0 for each of the metals, risk cannot be assumed *de minimis* based on this simple comparison alone. The LOAEL-based TQs are relatively low for all three metals, with none exceeding 1.0 for lead. As discussed with DEQ, additional context for risk management decisions can be provided through the probabilistic population-based analysis described in DEQ Level III guidance.

## 5.0 POPULATION-LEVEL PROBABILISTIC EVALUATION

Based on the relative distribution of chemicals and the relative sensitivity of the Level II assessment endpoints (i.e., birds), a supplemental population-level probabilistic evaluation provides additional information to determine if risk management actions are needed for metals that exceeded conservative screening values established by DEQ. This evaluation was conducted for birds, assuming that they are as sensitive, or more sensitive as mammals to the CPECs. Based on the potential future use of the Facility as industrial, it is assumed that population-level effects are conservative for most species and that the loss of a single individual is not critical to the population or community. The following sections summarize the population-level probabilistic analysis methodology and results.

The overall goal of the analysis (i.e., the risk hypothesis) was based on the DEQ Acceptable Risk Level (ARL) for non-T/E species (DEQ 2001; OAR 340-122-115(6)). Specifically, the analysis evaluated whether American robins would be exposed to CPECs in the area of consideration (called the contaminated area [CA] in DEQ guidance) at concentrations that may result in exposures that exceed the ARL. For non-T/E species, the ARL is defined as a probability greater than 10 percent (%), that 20% or more of the local population experiences exposures greater than the EBV for a given CPEC. Similarly to the expanded Level II analysis, the TQ is defined as the ratio of the exposure estimate to the EBV for each CPEC (DEQ 2001; OAR 340-122-115(5)). This analysis was conducted using the same exposure parameters and EBVs outlined in Section 4; refer to Tables 4-1 and 4-2.

### 5.1 Population-Level Exposure Analysis and Risk Estimation Methodology

The goal of the population-level exposure analysis is to estimate the rate at which representative receptors are exposed to CPECs in the CA (i.e., riverbank area). Estimating exposure for the endpoint receptor population requires defining local population boundaries, determining habitat size and quality, identifying exposure parameters (e.g., feeding range, body size, food ingestion rates) and estimating exposure. Estimating exposure, which is the dose of a hazardous substance occurring at a location of potential contact between an ecological receptor and the hazardous substance, is the focus of an exposure analysis (DEQ 2001).

To evaluate risks to non-T/E species, the focal population to be assessed should be an ecologically significant unit within the CA (Hope and Peterson 2000). Within the breeding season, terrestrial birds, such as the American robin, have relatively restricted feeding ranges during their time of residence at a site. Thus, American robins are likely to be resident at the riverbank area of the Facility and represent a local population exposed to affected soils. It is likely that the local robin population extends well beyond the Facility, and probably the

surrounding areas. However, assessment of the (sub) population in the riverbank area of the Facility provides a conservative measure of potential exposure for purposes of this ERA.

The population-level probabilistic risk analysis was performed in accordance with DEQ (2001; adapted from Hope and Peterson 2000) in Appendix F. The probabilistic risk evaluation involves: (1) estimating the number of individuals (n) of the receptor within the location population boundary; (2) estimating the probability (P) that an individual receptor will experience an exposure in excess of the EBV; (3) and calculating the probability that more than 20% of the local population will experience exposures greater than the EBV, and (4) assessing whether the ARL is exceeded. If the probability that more than 20% of the local population will experience exposures greater than the EBV is greater than 10%, then risk exceeds the ARL. Refer to DEQ (2001 and 2006c) for the specific equations developed for these calculations.

Using Geographic Information System (GIS) methodology, the calculated size of the CA (i.e., riverbank area – extending below property boundary to beach area) is 5.54 acres (2.24 hectare [ha]). Restricting the analysis to the riverbank area is conservative since the local robin subpopulation likely extends beyond the site. The assessment population area for the modeled receptors corresponds to 5 home-range (HR) diameters, and was calculated using Equation 2 in DEQ (2001):

$$A = (100 \cdot HR) / \pi$$

The annual average home range of the American Robin is 0.15 ha (USEPA 1993) and so the calculated “assessment population area” is estimated at 4.8 ha, which is larger than the CA (i.e., riverbank area). With an estimated average density of 5.16 pairs per ha (USEPA 1993), the modeled population size of American robins in the CA is approximately 49 individuals. As indicated previously, this exposure model assumes even and random access by receptors to all portions of the riverbank area.

The probability (P) that an individual receptor will experience an exposure in excess of the EBV was calculated using the following equation (DEQ 2006c):

$$P = \Phi_z(x_{exp} - \ln(EBV)/s_{exp})$$

where:

p = Probability of exposure > EBV (unitless)

$\phi Z$  = Cumulative distribution function of a standard normal random variable (MS-Excel® NORM.S.DIST function)

xEXP = Mean of exposure dose (mg/kg/day)

sEXP = Standard deviation of exposure dose (mg/kg/day)

EBV = Ecological Benchmark Value (mg/kg bw/day)

Where environmental data are found to be lognormally distributed instead of normally distributed, the log transformation of both the dose and the EBV are necessary.

The following equation (DEQ 2006c) is used to calculate b, the probability that more than 20% of the total local population will receive an exposure exceeding the TRV:

$$b = 1 - \sum_{i=0}^y \left[ \left( \frac{n!}{i!(n-i)!} \right) p^i (1-p)^{(n-i)} \right] = 1 - \text{BINOM.DIST}(y, n, p, \text{true})$$

where:

y = 20 percent of the population [y = INT(0.2n)]

n = size of the local population

p = probability of individual exposure > EBV

b = probability that more than 20% of the total population will have exposure > EBV

INT = MS-Excel® integer function

BINOM.DIST = MS-Excel® binomial distribution function (cumulative)

As used here, the cumulative BINOM.DIST function calculates the probability (b) that 20% or more (y) of the population will be exposed to a dose greater than the EBV. To calculate the probability that more than y percent of the population will be exposed to a dose greater than the EBV, the expression 1 – BINOM.DIST is used. The resulting probability is compared to the population-level ARL.

## 5.2 Population-Level Probabilistic Analysis Results

Results are summarized on Table 5-1 and Appendix F-1 through F-6 provides calculation worksheets for each CPEC, and provides separate calculations for discrete and composite samples. The interpretation of results without an LC50 value has not been established by DEQ, but the following rationale was used help interpret the results:

- If the probability of exceeding a mortality-based NOAEL is <0.1, then exposures cannot exceed the ARL for an LC50 value and risk should be considered acceptable.
- If the probability of exceeding a mortality-based LOAEL is <0.1, the LOAEL study endpoint is based on less than 50% mortality of test organisms, and the probabilities of exceeding reproduction/growth-based NOAELs and/or LOAELs is likely less than 0.1, then exposures probably do not exceed the ARL for an LC50 value and risk should be considered acceptable.
- If the probability of exceeding a mortality-based LOAEL is equal to or greater than 0.1, and the LOAEL is based on <50% mortality of test organisms, and the probabilities of exceeding reproduction/growth-based NOAELs and/or LOAELs are less than 0.1, then the LOAEL likely represents exposures less than the LC50, and risk should be considered acceptable. But specific conditions at the site (habitat, site size, relationship

to other habitats, and form of the chemical) should be considered and discussed with DEQ.

- If the probability of exceeding mortality-based LOAEL is equal to or greater than 0.1, and the LOAEL is based on equal to or greater than 50% mortality of test organisms and is at the higher end of the LOAEL spectrum, then the LOAEL could represent exposures equal to or greater than the ARL, and risk could be unacceptable. Indications of unacceptable risk increase as the number of LOAELs and NOAELs with probabilities >0.1 increase.

#### Results summary for Zinc:

In Table 4-2, the EBV value of 271 mg/Kg BW/day represents a geometric mean of the mortality based LOAELs values from studies included in USEPA EcoSSL development. The geometric mean is for studies that were at least 4 weeks in duration, and based on food-borne exposure to zinc. The probability of exceeding this value was far less than the ARL (0.1) for discrete and composite samples (Table 5-1). Note that the benchmark value of 87.1 was a LOAEL associated with about 43% mortality (3 out of 7) (Gibson et al, 1986). The probability of exceeding this level of exposure is estimated to be high (1.0). However, since the geometric mean of LOAELs represents a wider sampling of test results, it would seem to be a better indicator for the risk of toxicity.

#### Results summary for Lead:

The probability of lead exposure greater than the mortality-based NOAEL (22 mg/Kg BW/day) was less than 0.1. This EBV is the geometric mean of mortality-based NOAELs listed in the EcoSSL for lead (Table 5.1, EPA 2005), and so represents multiple studies that of high enough quality to be included in the EcoSSL analysis. These results indicate risk from lead to the local bird populations likely does not exceed ARLs.

#### Results summary for Copper:

Two mortality-based LOAELs were included in the EBVs (values of 42 and 68.4 mg/Kg BW/day in Table 4-2). The probability of exceeding the higher of the EBVs did not exceed 0.1 for either composite or discrete samples (Table 5-1). This EBV is based on a commonly cited reference for copper toxicity levels in birds, and corresponds to a mortality rate of about 40% (Mehring et al. 1960). The probability of exceeding the lower of the EBVs exceeded 0.1 for discrete, but not composite samples. The lower EBV is based on the geometric mean of mortality LOAELs from the Eco SSL document for copper (EPA 2007). The level of mortality among the references used in this mean is not known, but is probably less than 50%.

Overall, the probabilistic analysis indicates that risks from zinc, lead, and copper are below the ARL defined for population-level risk analysis because probability of exposures exceeding mortality-based LOAELs is less than 0.1. Since formally derived LC50/LD50s that are suitable

for this analysis were not available, NOAEL- and LOAEL-based analyses are substituted (Appendix G). The NOAEL, and probably the LOAEL, are lower exposure levels than the LC50/LD50 values identified for the Oregon ARL, and substitution of these benchmarks is likely more protective than use of the LC50/LD50 values. Therefore, if probability of exceeding a mortality-based LOAEL is less than 0.1, then risks for the site are likely to be below the ARL. Individuals that use contaminated point locations heavily may experience exposure exceeding the EBV, but the probabilistic analysis conducted using DEQ Level III guidance indicates that ARLs are not exceeded.

## **6.0 ECOLOGICAL RISK ASSESSMENT CONCLUSIONS**

### **6.1 Overall Level II ERA Conclusions**

Based on the Level I Scoping and Level II Screening processes, concentrations of copper (plants, invertebrates, birds, mammals), lead (birds), and zinc (plants, invertebrates, birds, mammals) exceed screening levels established by DEQ to prompt additional evaluation to support risk management decisions. Exceedance of the SLVs does not necessarily indicate unacceptable risk and ODEQ guidance identifies additional risk analysis steps that can be used to support risk management decisions. For SIUF OU2, the additional analysis included mapping locations at which concentrations exceeded SLVs for plants and invertebrates, and conducting expanded exposure and risk analysis for wildlife.

Exceedances for plants and invertebrates appear to be isolated in subsections of the site, suggesting that individuals in those locations may experience exposures greater than the SLVs. However, the locations with exceedances represent a relative small part of the site, limiting the area of the site in which toxicity may impair overall ecological functions. In addition, the relatively disturbed and ruderal nature of the vegetation community makes it unlikely that this area of riverbank and adjacent area provide substantial ecological function in the local ecosystem.

The expanded Level II exposure analysis and the population-level probabilistic evaluation suggests that exposure of birds could exceed some sublethal and mortality-based LOAEL EBVs, but do not exceed the ARL set by DEQ based on LC50/LD50 endpoints. Therefore, ecological risk at this site is within acceptable ranges and no remedial action is needed to protect ecological receptors and ecological function in the area.

### **6.2 Technical-Management Decision Points (TMDPs)**

According to DEQ guidance (2001), TMDPs are steps in the risk assessment process where one of three recommendations is determined: 1) no further ecological investigations at OU2; 2) continuation of the risk assessment process to the next level; or 3) undertake a removal or remedial action. DEQ guidance identifies two TMDPs at the end of the Level II screening process. The information gathered during the Level I Scoping and Level II Screening processes are used to evaluate TMDP 3 and TMDP 4, as discussed further here.

### 6.2.1 TMDP 3

This TMDP is intended to help determine whether unacceptable ecological risk is probable. According to DEQ guidance (2001), the potential for risk exists when CPECs are present and there are complete exposure pathways between contaminated media and ecological receptors. The Level I scoping indicated that the potential for exposure exists at riverbank areas of OU2 based on the presence of habitat, albeit of marginal quality, and possible contact of ecological receptors to contaminants transported to those areas. However, the guidance indicates that unacceptable risk is probable only if the locality exhibits the following three criteria: 1) contains any individuals of a T/E species, critical habitat of a T/E species, or contains habitat of sufficient size and quality to support a local population of non-T/E species; 2) CPECs were selected on the basis of exceedance of SLVs or because they have a high potential to bioaccumulate; and 3) there appears to be plausible links between CPEC sources and endpoint receptors (DEQ 2001).

As described in the Level I ERA, and referenced above, there are no known T/E species and the habitat size and quality at OU2 is currently relatively low. By itself, it may not be sufficient to support a self-propagating population of vertebrate wildlife receptors such as birds or mammals. The CPECs identified in the Level II screening evaluation were identified based on the exceedance of SLVs. However, the expanded Level II analysis and supplemental population-level probabilistic evaluations suggests low risk of toxic exposure to individuals at OU2, and low risk to local populations if the site exposure remains at current levels.

In terms of links between CPEC sources and endpoint receptors, OU2 is currently designated for industrial use and is expected to remain so for the foreseeable future. As a result, terrestrial wildlife receptors are unlikely to spend substantial amounts of time feeding or engaged in other behaviors that would result in substantial contact with soils in these upland areas at OU2. The riverbank areas of OU2 contain more extensive vegetation, but do not represent significant habitat for rare or important plant communities and include substantial portion of non-native species. Decisions regarding the probability of unacceptable risk from environmental media should include consideration of these factors. Based on these results, the probability of unacceptable ecological risk from upland soils is minimal, and does not warrant additional remediation at OU2.

### 6.2.2 TMDP 4

This TMDP assesses whether a remedial action decision is possible based on the existing information and current levels of uncertainty. Specifically, if cleanup would be less costly than further investigation and data are adequate to select and approve a remedy action, then further ecological investigation should be deferred in favor of a response action. The alternative is for the assessment process to proceed to Level III for further evaluation. Based on information gathered during the Level I Scoping and Level II Screening processes, including the expanded

Level II analysis and supplemental population-level probabilistic evaluations, the existing information is adequate to conclude that remediation at OU2 is not necessary based on ecological risk.

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## TABLES

**TABLE 3.1 Screening Level Summary Table**

Constituents of Interest (COIs)			Background Levels <sup>3</sup>	Plants			Invertebrates			Birds			Mammals		
CASNo	Analyte <sup>1</sup>	Analyte Group/Methods <sup>2</sup>		Oregon DEQ Level II SLVs <sup>4</sup> (mg/kg)	Oregon DEQ- Requested Alternative Screening Levels <sup>5</sup> (mg/kg)	Oregon DEQ- Approved Level II SLVs <sup>6</sup>	Oregon DEQ Level II SLVs <sup>4</sup> (mg/kg)	Oregon DEQ- Requested Alternative Screening Levels <sup>5</sup> (mg/kg)	Oregon DEQ- Approved Level II SLVs <sup>6</sup>	Oregon DEQ Level II SLVs <sup>4</sup> (mg/kg)	Oregon DEQ- Requested Alternative Screening Levels <sup>5</sup> (mg/kg)	Oregon DEQ- Approved Level II SLVs <sup>6</sup>	Oregon DEQ Level II SLVs <sup>4</sup> (mg/kg)	Oregon DEQ- Requested Alternative Screening Levels <sup>5</sup> (mg/kg)	Oregon DEQ- Approved Level II SLVs <sup>6</sup>
78763-54-9	Butyltin Ion	Butyltins	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
14488-53-0	Dibutyltin Ion	Butyltins	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1461-25-2	Tetrabutyltin Ion	Butyltins	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
688-73-3	Tributyltin	Butyltins	NA	NA	NA	NA	NA	NA	NA	28	NA	28	1300	NA	1300
7440-36-0	Antimony	Metals	4	5	NA	5	NA	78 <sup>d</sup>	78	NA	NA	NA	15	0.27 <sup>d</sup>	0.27
7440-38-2	Arsenic	Metals	7	10	18 <sup>d</sup>	18	60	NA	60	10	43 <sup>d</sup>	43	29	46 <sup>d</sup>	46
7440-39-3	Barium	Metals	NA	500	NA	500	3000	330 <sup>d</sup>	330	85	NA	85	638	2000 <sup>d</sup>	2000
7440-43-9	Cadmium	Metals	1	4	32 <sup>d</sup>	32	20	140 <sup>d</sup>	140	6	0.77 <sup>d</sup>	0.77	125	0.36 <sup>d</sup>	0.36
1308-38-9	Chromium	Metals	42	1	NA	1	0.4	NA	0.4	4	26 <sup>d</sup>	26	410	34 <sup>d</sup>	34
7440-50-8	Copper	Metals	36	100	70 <sup>d</sup>	70	50	80 <sup>d</sup>	80	190	28 <sup>d</sup>	28	390	49 <sup>d</sup>	49
7439-92-1	Lead	Metals	17	50	120 <sup>d</sup>	120	500	1700 <sup>d</sup>	1700	16	11 <sup>d</sup>	11	4000	56 <sup>d</sup>	56
7439-97-6	Mercury	Metals	0.07	0.3	NA	0.3	0.1	NA	0.1	1.5	NA	1.5	73	NA	73
7440-02-0	Nickel	Metals	38	30	38 <sup>d</sup>	38	200	280 <sup>d</sup>	280	320	210 <sup>d</sup>	210	625	130 <sup>d</sup>	130
7782-49-2	Selenium	Metals	2	1	0.52 <sup>d</sup>	0.52	70	4.1 <sup>d</sup>	4.1	2	1.2 <sup>d</sup>	1.2	25	0.63 <sup>d</sup>	0.63
7440-22-4	Silver	Metals	1	2	560 <sup>d</sup>	560	50	NA	50	NA	4.2 <sup>d</sup>	4.2	NA	14 <sup>d</sup>	14
7440-66-6	Zinc	Metals	86	50	160 <sup>d</sup>	160	200	120 <sup>d</sup>	120	60	46 <sup>d</sup>	46	20000	79 <sup>d</sup>	79
132-64-9	Dibenzofuran	PAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.002	NA	0.002
90-12-0	1-Methylnaphthalene	PAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
91-57-6	2-Methylnaphthalene	LPAHs	NA	10	NA	10	NA	NA	NA	NA	NA	NA	3900	NA	3900
83-32-9	Acenaphthene	LPAHs	NA	20	NA	20	NA	NA	NA	NA	NA	NA	3900	NA	3900
208-96-8	Acenaphthylene	LPAHs	NA	10	NA	10	NA	NA	NA	NA	NA	NA	3900	NA	3900
120-12-7	Anthracene	LPAHs	NA	10	NA	10	NA	NA	NA	NA	NA	NA	3900	NA	3900
56-55-3	Benz(a)anthracene	HPAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	125	NA	125
50-32-8	Benzo(a)pyrene	HPAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	125	NA	125
205-99-2	Benzo(b)fluoranthene	HPAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	125	NA	125
191-24-2	Benzo(g,h,i)perylene	HPAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	125	NA	125
207-08-9	Benzo(k)fluoranthene	HPAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	125	NA	125
218-01-9	Chrysene	HPAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	125	NA	125
53-70-3	Dibenz(a,h)anthracene	HPAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	125	NA	125
206-44-0	Fluoranthene	HPAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	125	NA	125
86-73-7	Fluorene	LPAHs	NA	10	NA	10	30	NA	30	NA	NA	NA	3900	NA	3900
193-39-5	Indeno(1,2,3-cd)pyrene	HPAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	125	NA	125
91-20-3	Naphthalene	LPAHs	NA	10	NA	10	NA	NA	NA	NA	NA	NA	3900	NA	3900
85-01-8	Phenanthrene	LPAHs	NA	10	NA	10	NA	NA	NA	NA	NA	NA	3900	NA	3900
129-00-0	Pyrene	HPAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	125
LPAH	Low-Molecular Weight PAHs (sum) <sup>a</sup>	LPAHs	NA	NA	NA	NA	NA	29 <sup>d</sup>	29	NA	NA	NA	NA	100	100
HPAH	High-Molecular Weight PAHs (sum) <sup>a</sup>	HPAHs	NA	NA	NA	NA	NA	18 <sup>d</sup>	18	NA	NA	NA	NA	1.1	1.1
12674-11-2	Aroclor 1016	PCBs	NA	NA	NA	NA	NA	NA	NA	0.7	NA	0.7	100	NA	100
11104-28-2	Aroclor 1221	PCBs	NA	NA	NA	NA	NA	NA	NA	0.7	NA	0.7	4	NA	4
11141-16-5	Aroclor 1232	PCBs	NA	NA	NA	NA	NA	NA	NA	0.7	NA	0.7	4	NA	4
53469-21-9	Aroclor 1242	PCBs	NA	NA	NA	NA	NA	NA	NA	1.5	NA	1.5	5	NA	5
12672-29-6	Aroclor 1248	PCBs	NA	NA	NA	NA	NA	NA	NA	0.7	NA	0.7	4	NA	4
11097-69-1	Aroclor 1254	PCBs	NA	NA	NA	NA	NA	NA	NA	0.7	NA	0.7	4	NA	4
11096-82-5	Aroclor 1260	PCBs	NA	NA	NA	NA	NA	NA	NA	0.7	NA	0.7	4	NA	4
37324-23-5	Aroclor 1262	PCBs	NA	NA	NA	NA	NA	NA	NA	0.7	NA	0.7	4	NA	4
11100-14-4	Aroclor 1268	PCBs	NA	NA	NA	NA	NA	NA	NA	0.7	NA	0.7	4	NA	4
1336-36-3	Total Aroclors <sup>c</sup>	PCBs	NA	40	40 <sup>f</sup>	40	NA	NA	NA	NA	0.65 <sup>f</sup>	0.65	4	0.65 <sup>f</sup> ; 0.371 <sup>f</sup>	0.371
117-81-7	Bis(2-ethylhexyl) Phthalate	Phthalates	NA	NA	NA	NA	NA	NA	NA	4.5	NA	4.5	1020	0.925 <sup>g</sup>	0.925
85-68-7	Butyl Benzyl Phthalate	Phthalates	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.239 <sup>g</sup>	0.239
84-66-2	Diethyl Phthalate	Phthalates	NA	100	NA	100	200	NA	200	NA	NA	NA	250000	24.8 <sup>g</sup>	24.8
131-11-3	Dimethyl Phthalate	Phthalates	NA	100	NA	100	200	NA	200	NA	NA	NA	250000	734 <sup>g</sup>	734

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CASNo	Analyte <sup>1</sup>	Analyte Group/Methods <sup>2</sup>		Oregon DEQ Level II SLVs <sup>4</sup> (mg/kg)	Oregon DEQ- Requested Alternative Screening Levels <sup>5</sup> (mg/kg)	Oregon DEQ- Approved Level II SLVs <sup>6</sup>	Oregon DEQ Level II SLVs <sup>4</sup> (mg/kg)	Oregon DEQ- Requested Alternative Screening Levels <sup>5</sup> (mg/kg)	Oregon DEQ- Approved Level II SLVs <sup>6</sup>	Oregon DEQ Level II SLVs <sup>4</sup> (mg/kg)	Oregon DEQ- Requested Alternative Screening Levels <sup>5</sup> (mg/kg)	Oregon DEQ- Approved Level II SLVs <sup>6</sup>	Oregon DEQ Level II SLVs <sup>4</sup> (mg/kg)	Oregon DEQ- Requested Alternative Screening Levels <sup>5</sup> (mg/kg)	Oregon DEQ- Approved Level II SLVs <sup>6</sup>
84-74-2	Di-n-butyl Phthalate	Phthalates	NA	200	NA	200	NA	NA	NA	0.45	NA	0.45	30000	0.15 <sup>9</sup>	0.15
117-84-0	Di-n-octyl Phthalate	Phthalates	NA	NA	NA	NA	NA	NA	NA	0.45	NA	0.45	30000	709 <sup>9</sup>	709
HORHC	Heavy Oil Range Hydrocarbons	TPH (418.1)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diesel	Diesel	TPH (HCID)	NA	NA	NA	NA	NA	200 <sup>°</sup>	200	NA	6000 <sup>°</sup>	6000	NA	6000 <sup>°</sup>	6000
Gasoline	Gasoline	TPH (HCID)	NA	NA	NA	NA	NA	100 <sup>°</sup>	100	NA	5000 <sup>°</sup>	5000	NA	5000 <sup>°</sup>	5000
Oil	Oil	TPH (HCID)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diesel	Diesel	TPH (NWTPH-Dx)	NA	NA	NA	NA	NA	200 <sup>°</sup>	200	NA	6000 <sup>°</sup>	6000	NA	6000 <sup>°</sup>	6000
Oil	Oil	TPH (NWTPH-Dx)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gasoline	Gasoline	TPH (NWTPH-Gx)	NA	NA	NA	NA	NA	100 <sup>°</sup>	100	NA	5000 <sup>°</sup>	5000	NA	5000 <sup>°</sup>	5000

Notes :

1 - Notes about summed analytes:

- a - Sum of Low Molecular Weight PAHs (LPAHs): Sum of the detected LPAHs or the highest detection limit when not detected. LPAHs have three or fewer aromatic rings and include: 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluorene, Naphthalene, Phenanthrene. 1-Methylnaphthalene was not included in the sum.
- b - Sum of High Molecular Weight PAHs (HPAHs): Sum of the detected HPAHs or the highest detection limit when not detected. HPAHs have four or more aromatic rings and include: Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Pyrene. Dibenzofuran was not included in the sum.
- c- Total Aroclors: Sum of the detected Aroclors or the highest detection limit when not detected.

2 - Notes about analyte types/methods:

Metals analysis by U.S. Environmental Protection Agency (EPA) 6000/7000 Series Methods

Polynuclear Aromatic Hydrocarbons (PAHs) by U.S. Environmental Protection Agency (EPA) Method 8270 C SIM

Phthalates by U.S. Environmental Protection Agency (EPA) Method 8270C

Polychlorinated Biphenyl (PCB) Aroclors by U.S. Environmental Protection Agency (EPA) Method 8082

Butyltins by Krone Method

TPH results from different analytical methods kept separate.

TPH-Gx = Gasoline-range Total Petroleum Hydrocarbons (TPH) by Northwest Method NWTPH-Gx

TPH-Dx = Diesel-range Total Petroleum Hydrocarbons (TPH) by Northwest Method NWTPH-Dx (with silica gel cleanup)

HCID = Total Petroleum Hydrocarbons (TPH) Identification by Northwest Method NWTPH-HCID

418.1 =Total Petroleum Hydrocarbons (TPH) by EPA Method 418.1

3 - Background levels: Oregon Department of Environmental Quality (DEQ). 2002. DEQ Toxicology Workgroup Memorandum to DEQ Cleanup Project Managers regarding "Default background concentrations for metals". October 28, 2002.

4 - Oregon DEQ Level II Screening Level Values (SLV) from Oregon Department of Environmental Quality (DEQ). 2001. Guidance for Ecological Risk Assessment: Levels I, II, III, IV. Waste Management & Cleanup Division, Final April 1998, updated May 2001.

chromium VI SLV applied to chromium

mercury (elemental, total) SLV applied to mercury

arsenic III SLV applied to arsenic

Aroclor 1254 SLV applied to Aroclors without criteria

naphthalene SLV applied to LPAHs without criteria

di-n-butyl phthalate SLV applied to di-n-octyl phthalate

tributyltin oxide SLV applied to tri-n-butyltin

diethyl phthalate SLV applied to dimethyl phthalate

chromium III SLV applied to chromium

benzo(a)pyrene SLV applied to HPAHs without criteria

5 - In June 6, 2012, Oregon DEQ provided input during a conference call on requested alternative screening values because DEQ soil values are currently outdated for several SLVs.

- d - Oregon DEQ requested that for metals and PAHs, USEPA Ecological Soil Screening Levels (EcoSSLs) should be used instead of DEQ SLVs. Source: U.S. Environmental Protection Agency (USEPA). 2005. Guidance for Developing Ecological Soil Screening Levels (EcoSSLs). USEPA Office of Solid Waste and Emergency Response (OSWER), OSWER Directive 9285.7-55. Published November 2003, Revised November 2005 and subsequent contaminant-specific EcoSSL documents.
- e - Oregon DEQ requested that TPH values are available from Washington Department of Ecology Model Toxics Control Act (MTCA). Source: Washington State Department of Ecology (WDOE). 2012. Table 749-3: Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals. Available at: [http://www.ecy.wa.gov/programs/tcp/policies/terrestrial/table\\_749-3.pdf](http://www.ecy.wa.gov/programs/tcp/policies/terrestrial/table_749-3.pdf). From: Table Terrestrial Ecological Evaluation (TEE) Process - The Site-Specific Evaluation. Available at: <http://www.ecy.wa.gov/programs/tcp/policies/terrestrial/site-specific.htm>. Toxics Cleanup Program, Model Toxics Control Act (MTCA) Regulation. Accessed 6/19/2012. Values for "wildlife" were applied to both birds and mammals.
- f - Oregon DEQ requested that for PCBs, the ERA should evaluate a bioaccumulation screening level value, which are available from Oak Ridge National Laboratory (ORNL) or Washington Department of Ecology (WDOE) Model Toxics Control Act (MTCA). ORNL source: Efromson, R.A., Suter, G.W.II, Sample, B.E., and Jones, D.S. 1997. 1997. Table 4: Preliminary Remediation Goals for Soils, in Preliminary Remediation Goals for Ecological Endpoints. Prepared for the U.S. Department of Energy, Office of Environmental Management. Available at [http://www.clu-in.org/download/contaminantfocus/dnapl/Toxicology/doe\\_prg\\_tm162r2.pdf](http://www.clu-in.org/download/contaminantfocus/dnapl/Toxicology/doe_prg_tm162r2.pdf). August 1997. Value for total aroclors is based on exposures to shrews (and the document indicates "toxic concentration benchmarks are not available for earthworms. Therefore, the PRG cannot be assumed to protect earthworms."), and so the value was applied to mammals only.
- WDOE source: Washington State Department of Ecology (WDOE). 2012. Table 749-3: Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals. Available at: [http://www.ecy.wa.gov/programs/tcp/policies/terrestrial/table\\_749-3.pdf](http://www.ecy.wa.gov/programs/tcp/policies/terrestrial/table_749-3.pdf). From: Table Terrestrial Ecological Evaluation (TEE) Process - The Site-Specific Evaluation. Available at: <http://www.ecy.wa.gov/programs/tcp/policies/terrestrial/site-specific.htm>. Toxics Cleanup Program, Model Toxics Control Act (MTCA) Cleanup Regulation. Accessed 6/19/2012. Values for "wildlife" were applied to both birds and mammals.
- g - Oregon DEQ requested that for phthalates, EPA Region 5 provides additional SLVs for soil. Source: U.S. Environmental Protection Agency (USEPA). 2003. Region 5 RCRA Corrective Action, Ecological Screening Levels. Available at <http://www.epa.gov/Region5/waste/cars/esl.htm>. August 2003. The ESLs represent a protective benchmark (e.g., chronic no adverse effect levels); soil ecological screening levels are based on exposure to the Masked Shrew (Sorex cinerus). In this assessment, criteria are applied to mammals only.

6 - The final Oregon DEQ-approved Level II Screening Level Value (SLV) to be used in the risk evaluation is the Oregon DEQ-requested alternative value (footnote 5) where available, then the Oregon DEQ SLVs (Oregon DEQ 2001; footnote 4).

## TABLE 3-2 Summary of CPECs - Riverbank Soils

### Swan Island OU2 Upland Facility - Riverbank Soils - Oregon Screening Levels (Ecological Receptors)

Candidate CPECs	Plants <sup>1</sup>	Invertebrates <sup>1</sup>
	MDC	MDC
Chromium	YES	YES
Copper	YES	YES
Zinc	YES	YES

1 - For plants and invertebrates, CPECs are COIs whose MDCs exceed an Oregon DEQ-approved Level II SLV at the Q=5 level for non-T/E species and background levels, as indicated with highlighting.

Candidate CPECs	Birds <sup>2</sup>		Mammals <sup>2</sup>	
	90UCL (composite)	90UCL (discrete)	90UCL (composite)	90UCL (discrete)
Copper	YES	YES	YES	NO
Lead	YES	YES	NO	NO
Zinc	YES	YES	NO	YES
High-Molecular Weight PAHs (sum)	NO	NO	NO	NO

2 - For birds and mammals, CPECs are COIs whose 90UCLs exceed an Oregon DEQ-approved Level II SLV at the Q=5 level for non-T/E species and background levels, as indicated with highlighting.

#### Notes:

CPECs - contaminants of potential ecological concern

SLV - screening level value

DEQ - Oregon Department of Environmental Quality

MDC - maximum detected concentration

90UCL - 90% upper confidence limit

HQ - hazard quotient

T/E - threatened/endangered

**TABLE 4-1 Approach for Calculation of Estimated CPEC Intake for Modeled Receptor - American Robin**

**Swan Island OU2 Upland Facility Riverbank Soils**

**Modeled Receptor:** American Robin

**Intake Equations:**

Equation (a) - total CPEC intake

$$Intake_{total} = Intake_{food} + Intake_{water} + Intake_{soil}$$

Parameters - Equation (a):

Parameter	Description	Units	Value	Source/Notes
Intake <sub>food</sub>	average daily intake from ingestion of prey items (vegetation and animal tissues).	mg/kg	calculated	See Equation (b)
Intake <sub>soil</sub>	average daily intake from incidental ingestion of surface soil.	mg/kg	calculated	See Equation (c)
Intake <sub>water</sub>	average daily intake from the ingestion of water.	mg/kg	0	No surface water at Upland Facility; water intake assumed to be 0.

Equation (b) - CPEC intake from food

$$Intake_{food} = AUF * \left( \sum_{i=1}^N B_{ij} * P_i * FIR \right)$$

Parameters - Equation (b):

Parameter	Description	Units	Value	Source/Notes
Intake <sub>food</sub>	Intake for contaminant (j) in food	mg dw/kg bw-d	calculated	
AUF	Area use factor	unitless	1	Fraction of food derived from site; area use assumed to be 100%
FIR	Food intake rate	kg dw/kg bw-d	0.207	WDOE 2012 - food ingestion rate for American Robin
B <sub>ij</sub>	Concentration of contaminant (j) in biota type (i) where $\ln(B_{ij}) = \text{Intercept}_{ij} + \text{Slope}_{ij} * \ln(\text{Soil}_i)$	mg/kg dw	Copper: $\ln(B_{plants}) = (0.394 * \ln(\text{Soil}_i)) + 0.668$	Plant concentration equations from Bechtel-Jacobs 1998 and invertebrate concentration equations from Sample et al. 1999, as recommended in EPA 2005
			Copper: $B_{inverts} = 0.515 * \text{Soil}_i$	
			Lead: $\ln(B_{plants}) = (0.561 * \ln(\text{Soil}_i)) - 1.328$	
			Lead: $\ln(B_{inverts}) = (0.807 * \ln(\text{Soil}_i)) - 0.218$	
			Zinc: $\ln(B_{plants}) = (0.554 * \ln(\text{Soil}_i)) + 1.575$	
			Zinc: $\ln(B_{inverts}) = (0.328 * \ln(\text{Soil}_i)) + 4.449$	
N	total number of ingested prey types	unitless	2	EPA 1993 - American robin diet
P <sub>i</sub>	fraction of food as prey type <sub>i</sub>	unitless	Plants - 0.29	EPA 1993 - American robin diet
			Invertebrates - 0.71	

**TABLE 4-1 Approach for Calculation of Estimated CPEC Intake for Modeled Receptor - American Robin**

**Swan Island OU2 Upland Facility Riverbank Soils**

**Equation (c) - CPEC intake from ingested soil**

$$Intake_{soil} = AUF * (FIR * P_s * C_{js} * AF_{js})$$

**Parameters - Equation (c):**

Parameter	Description	Units	Value	Source/Notes
Intake <sub>soil</sub>	Intake for contaminant (j) in soil	mg dw/kg bw-d	calculated	
C <sub>js</sub>	Concentration of contaminant (j) in soil (s)	mg/kg dw	available data	All available site-wide sample data
FIR	Food intake rate	kg dw/kg bw-d	0.207	WDOE 2012 - food ingestion rate for American Robin
P <sub>s</sub>	Proportion of total mass intake that is soil	kg soil/kg food	15.15%	EPA 2005 - average of 90th percentile values for avian granivore and avian insectivore <sup>1</sup>
AF <sub>js</sub>	Bioavailability factor of contaminant (j) in soil	unitless	Zinc: 1	Bioavailability of zinc and copper from ingested food was conservatively assumed to be 100%. Bioavailability of lead from soils was assumed to be 50%; lead bioavailability from ingested food was assumed to be 100% <sup>2</sup>
			Lead: 0.5	
			Copper: 1	
P <sub>i</sub>	Fraction of food as prey type <sub>i</sub>	unitless	Plants - 0.29	EPA 1993 - American robin diet
			Invertebrates - 0.71	
AUF	Area use factor	unitless	1	Fraction of food derived from site; area use assumed to be 100%

Notes:

1 - Mourning dove and American woodcock are surrogate species for avian granivore and avian insectivore, respectively.

2- The assimilation efficiency or bioavailability of zinc and copper in ingested soils or biota was conservatively assumed to be 100%. This is a conservative estimate since the bioavailability of most metals is less, especially directly from incidentally ingested soils or soils in gut content of prey items. The exception is lead, where bioavailability from soils was assumed to be 50%; lead bioavailability from ingested food was assumed to be 100%. These assumptions are conservative in that actual lead bioavailability can be much lower, especially from inorganic forms of lead ore or mill tailings (Ruby et al. 1992), and lead iron oxides that tend to form in soils from soluble forms of lead (Suedel et al. 2006, Schoof 2003). Lead carbonates and organic forms have higher bioavailability (80%) (Suedel et al. 2006, Schoof 2003).

mg - milligram      dw - dry weight  
kg - kilogram      bw - body weight  
d - day

Sources:

Bechtel-Jacobs. 1998. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Bechtel-Jacobs Company LLC, Oak Ridge, TN. BJC/OR-133.

Ruby, M.V., A. Davis, J.H. Kempton, J.W. Drexler, and P.D. Bergstrom. 1992. Lead Bioavailability: Dissolution Kinetics under Simulated Gastric Conditions. Environmental Science and Technology. 26:1242-1248.

Sample B.E., J.J. Beauchamp, R.A. Efroymsen, G.W. Suter, II, and T.L. Ashwood. 1999. Literature-derived bioaccumulation models for earthworms: development and validation. Environmental Toxicology and Chemistry 18: 2110-2120.

Schoof, R.A. 2003. Guide for Incorporating Bioavailability Adjustments into Human Health and Ecological Risk Assessments at U. S. Department of Defense Facilities Part 1: Overview of Metals Bioavailability (Final).

Suedel, B.C., A. Nicholson, C.H. Day, J. Spicer II. 2006. The value of metals bioavailability and speciation in formation for ecological risk assessment in arid soils. Integrated Environmental Assessment and Management. 2:355-364.

United States Environmental Protection Agency (EPA). 1993. Wildlife Exposure Factors Handbook. EPA/600/R-93/1987a. Volumes I & II.

United States Environmental Protection Agency (EPA). 2005. Attachment 4-1, Guidance for Developing Ecological Soil-Screening Levels (Eco-SSLs), OSWER Directive 9285.7-55 (issued November 2003, revised February 2005).

**TABLE 4-2 Ecological Benchmark Values (EBVs)****Swan Island OU2 Upland Facility Riverbank Soils****Modeled Receptor:** American Robin

Analyte	Ecological Benchmark Value	Units	Type of Value	Source/Notes
Zinc	14.5	mg dw/kg bw-d	Rep/Gro NOAEL	Sample et al. 1996 - NOAEL based on avian toxicity data related to reproduction endpoints (food exposure duration for at least 10 weeks; zinc sulfate consumption by white leghorn hens; Stahl et al. 1990).
	55.0		Rep/Gro NOAEL	Geometric mean of NOAELs for reproduction/growth endpoints from studies of food consumption exposure over long duration (at least 10 weeks) (from Table 5-1 EPA 2007a)
	66.1		Rep/Gro NOAEL	"A geometric mean of the NOAEL values for reproduction and growth" (Figure 5-1 in EPA 2007a). This value is lower than the lowest bounded LOAEL for reproduction, growth, or survival.
	68.8		Mor NOAEL	NOAEL for mortality endpoint from one study of food consumption exposure over 10 weeks (Gibson et al 1986 cited in Table 5-1 EPA 2007a).
	87.1		Mor LOAEL	LOAEL for mortality endpoint from one study of food consumption exposure over 10 weeks (Gibson et al 1986 cited in Table 5-1 EPA 2007a).
	110.5		Rep/Gro LOAEL	Geometric mean of LOAELs for reproduction/growth endpoints from studies of food consumption exposure over long duration (from Table 5-1 EPA 2007)
	131		Rep/Gro LOAEL	Sample et al. 1996 - LOAEL based on avian toxicity data related to reproduction endpoints (food exposure duration for at least 10 weeks; zinc sulfate consumption by white leghorn hens; Stahl et al. 1990)
	144.8		Mor NOAEL	Geometric mean of NOAELs for mortality endpoint from studies of food consumption with an exposure duration of 4 weeks or more (from Table 5-1 EPA 2007)
	271		Mor NOAEL	Geometric mean of LOAELs for mortality endpoint from studies of food consumption with an exposure duration of 4 weeks or more (from Table 5-1 EPA 2007)
Lead	1.1	mg dw/kg bw-d	Rep/Gro NOAEL	Sample et al. 1996 - NOAEL based on avian toxicity data related to reproduction endpoints (food exposure duration for at least 10 weeks; lead acetate consumption by quail; Edens et al. 1976)
	1.6		Rep/Gro/M or NOAEL	"Highest bounded NOAEL, lower than lowest bounded LOAEL for reproduction, growth, or survival" (Figure 5-1 in EPA 2005)
	10.9		Rep/Gro NOAEL	"Geometric mean of NOAELs for reproduction and growth" (Figure 5-1 in EPA 2005)
	11.3		Rep/Gro LOAEL	Sample et al. 1996 - LOAEL based on avian toxicity data related to reproduction endpoints (food exposure duration for at least 10 weeks; lead acetate consumption by quail; Edens et al. 1976)
	22.0		Mor NOAEL	Geometric mean of NOAELs for mortality endpoints from studies of food consumption exposure over long duration (from Table 5-1 EPA 2005); two studies.
Copper	4.05	mg dw/kg bw-d	Rep/Gro/M or NOAEL	"Highest bounded NOAEL, lower than lowest bounded LOAEL for reproduction, growth, or survival" (Figure 5-1 in EPA 2007b)
	18.5		Rep/Gro NOAEL	"Geometric mean of NOAELs for reproduction and growth" (Figure 5-1 in EPA 2007b)
	20.8		Rep/Gro NOAEL	Geometric mean of NOAELs for reproduction/growth endpoints from studies of food consumption exposure over long duration (at least 10 weeks) (from Table 5-1 EPA 2007b)
	22		Mor NOAEL	Geometric mean of NOAELs for mortality endpoint from studies of food consumption with an exposure duration of 4 weeks or more (from Table 5-1 EPA 2007b)
	28.7		Rep/Gro LOAEL	Geometric mean of LOAELs for reproduction/growth endpoints from studies of food consumption exposure over long duration (at least 10 weeks) (from Table 5-1 EPA 2007b)
	42		Mor LOAEL	Geometric mean of LOAELs for mortality endpoint from studies of food consumption with an exposure duration of 4 weeks or more (from Table 5-1 EPA 2007b)
	68.4		Mor LOAEL	Mehring et al. 1960 - LOAEL mortality dose calculated from highest dose in study (1180 mg/Kg; food exposure duration for at least 10 weeks; copper oxide consumption by chicks), which resulted in 40% mortality. The dose was calculated using food ingestion rate and body weight information from EPA (2007b).

Notes:

EBV = Ecological Benchmark Value

mg dw/kg bw-d = milligrams of dry weight per kilogram of body weight per day

LOAEL = Lowest Observed Adverse Effects Level

NOAEL = No Observed Adverse Effects Level

Rep/Gro = Reproductive/Growth

## TABLE 4-2 Ecological Benchmark Values (EBVs)

### Swan Island OU2 Upland Facility Riverbank Soils

Mor = Mortality  
na = not available

#### Sources:

Edens, F., W.E. Benton, S.J. Bursian, and G.W. Morgan. 1976. Effect of dietary lead on reproductive performance in Japanese quail, *Coturnix coturnix japonica*. Toxicol. Appl. Pharmacol. 38: 307-314.

Gibson, S. W., Stevenson, Mary H., and Jackson, N. 1986. Comparison of the effects of feeding diets supplemented with zinc oxide or zinc acetate on the performance and tissue mineral content of mature female fowls. Br. Poult. Sci. (1986) 27(3): 391-402 . Ref No. 6048.

Mehring, A.L., Jr., J.H. Brumbaugh, A.J. Sutherland, H.W. Titus. 1960. The tolerance of growing chickens for dietary copper. Poultry Science 39: 713-719.

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Stahl, J. L., J. L. Greger, and M. E. Cook. 1990. Breeding-hen and progeny performance when hens are fed excessive dietary zinc. Poult. Sci. 69: 259-263.

United States Environmental Protection Agency (EPA). 2007a. Ecological Soil Screening Levels for Zinc, Interim Final. OSWER Directive 9285.7-73 (June 2007).

United States Environmental Protection Agency (EPA). 2007b. Ecological Soil Screening Levels for Copper, Interim Final. OSWER Directive 9285.7-68 (Issued July 2006; Revised February 2007).

United States Environmental Protection Agency (EPA). 2005. Ecological Soil Screening Levels for Lead, Interim Final. OSWER Directive 9285.7-70 (March 2005).

**TABLE 4-3 Exposure Calculation and Comparison to EBVs**

**Swan Island OU2 Upland Facility Riverbank Soils**

**Modeled Receptor:** American robin, insectivorous bird

**Toxicity quotient calculations**

Constituent of Interest (COI)	EPC-90UCL		Exposure Estimate (mg/kg BW/ day)	EBV (mg/kg BW/ day)	Type of EBV	Toxicity Quotient (TQ)
	(mg/kg)	Basis				
Zinc	536.9	Composite samples	156.01	14.5	Rep/Gro NOAEL	10.8
				55	Rep/Gro NOAEL	2.8
				66.1	Rep/Gro NOAEL	2.4
				68.8	Mor NOAEL	2.3
				87.1	Mor LOAEL	1.8
				110.5	Rep/Gro LOAEL	1.4
				131	Rep/Gro LOAEL	1.2
				144.8	Mor NOAEL	1.1
				271	Mor LOAEL	0.6
	296.1	Discrete samples	123.78	14.5	Rep/Gro NOAEL	8.5
				55.0	Rep/Gro NOAEL	2.2
				66.1	Rep/Gro NOAEL	1.9
				68.8	Mor NOAEL	1.8
				87.1	Mor LOAEL	1.4
				110.5	Rep/Gro LOAEL	1.1
				131.0	Rep/Gro LOAEL	0.9
				144.8	Mor NOAEL	0.9
				271	Mor LOAEL	0.5
	86.00	Background Concentration	79.02	14.5	Rep/Gro NOAEL	5.4
				55.0	Rep/Gro NOAEL	1.4
				66.1	Rep/Gro NOAEL	1.2
				68.8	Mor NOAEL	1.1
				87.1	Mor LOAEL	0.9
				110.5	Rep/Gro LOAEL	0.7
				131.0	Rep/Gro LOAEL	0.6
				144.8	Mor NOAEL	0.5
				271	Mor LOAEL	0.3

Constituent of Interest (COI)	EPC-90UCL		Exposure Estimate (mg/kg BW/ day)	EBV (mg/kg BW/ day)	Type of EBV	Toxicity Quotient (TQ)
	(mg/kg)	Basis				
Lead	57.7	Composite samples	5.30	1.1	Rep/Gro NOAEL	4.7
				1.6	Rep/Gro/Mor NOAEL	3.3
				10.9	Rep/Gro NOAEL	0.5
				11.3	Rep/Gro LOAEL	0.47
				22.0	Mor NOAEL	0.24
	85.4	Discrete samples	7.37	1.1	Rep/Gro NOAEL	6.5
				1.6	Rep/Gro/Mor NOAEL	4.5
				10.9	Rep/Gro NOAEL	0.7
				11.3	Rep/Gro LOAEL	0.7
				22.0	Mor NOAEL	0.3
	17.00	Background Concentration	1.90	1.1	Rep/Gro NOAEL	1.7
				1.6	Rep/Gro/Mor NOAEL	1.2
				10.9	Rep/Gro NOAEL	0.2
				11.3	Rep/Gro LOAEL	0.2
				22.0	Mor NOAEL	0.1

**TABLE 4-3 Exposure Calculation and Comparison to EBVs**

**Swan Island OU2 Upland Facility Riverbank Soils**

Constituent of Interest (COI)	EPC-90UCL		Exposure Estimate (mg/kg BW/ day)	EBV (mg/kg BW/ day)	Type of EBV	Toxicity Quotient (TQ)
	(mg/kg)	Basis				
Copper	171.0	Composite samples	23.59	4.05	Rep/Gro/Mor NOAEL	5.8
				18.5	Rep/Gro NOAEL	1.3
				20.8	Rep/Gro NOAEL	1.1
				22	Mor NOAEL	1.1
				28.7	Rep/Gro LOAEL	0.8
				42	Mor LOAEL	0.6
				68.4	Mor LOAEL	0.3
	529.4	Discrete samples	73.04	4.05	Rep/Gro/Mor NOAEL	18.0
				18.5	Rep/Gro NOAEL	3.9
				20.8	Rep/Gro NOAEL	3.5
				22	Mor NOAEL	3.3
				28.7	Rep/Gro LOAEL	2.5
				42	Mor LOAEL	1.7
				68.4	Mor LOAEL	1.1
	36.0	Background Concentration	4.97	4.05	Rep/Gro/Mor NOAEL	1.2
				18.5	Rep/Gro NOAEL	0.3
				20.8	Rep/Gro NOAEL	0.2
				22	Mor NOAEL	0.2
				28.7	Rep/Gro LOAEL	0.2
				42	Mor LOAEL	0.1
				68.4	Mor LOAEL	0.1

**Parameters**

Exposure Parameters	Value	Unit
IRsoil	0.1515	kg soil/kg food
IRfood	0.207	kg dw/kg bw-d
Pplant	0	fraction
Pinverts	1	fraction
Soil bioavailability factor - zinc & copper	1	unitless
Soil bioavailability factor - lead	0.5	

Notes:

EPC = Exposure Point Concentration

EBV = Exposure Benchmark Value

TQ - Toxicity Quotient

90UCL = 90th upper confidence limit

Refer to Tables 4-1 and 4-2 for all exposure parameters, EBVs, and equations

# Summary Table 5-1 for Population-level Probabilistic Risk Analyses

## Swan Island OU2 Upland Facility

Modeled Receptor: American Robin, 100% Invertebrate Diet

Given the concentrations at the site, probability that more than 20% of the local population will experience Exposure > EBV

Acceptable Risk Level (ARL) for non T/E Species: probability < 0.1

Analyte	Ecological Benchmark Value (mg/kg bw/day)	Type of Value	Based on Discrete Samples	Based on Composite Samples
Zinc	14.5	Rep/Gro NOAEL	1	1*
	66.1	Rep/Gro/Mor NOAEL	1	1
	55	Rep/Gro NOAEL	1	1
	68.8	Mor NOAEL	1	1
	87.1	Mor LOAEL	1	1
	110.5	Rep/Gro LOAEL	0.72	1
	131	Rep/Gro LOAEL	0.004	0.98
	144.8	Mor NOAEL	<0.00001	0.49
	271	Mor LOAEL	<0.00001	<0.00001
Lead	1.13	Rep/Gro NOAEL	1.00	1.00
	1.63	Rep/Gro/Mor NOAEL	1.00	1.00
	10.9	Rep/Gro NOAEL	0.03	<0.00001
	11.3	Rep/Gro LOAEL	0.02	<0.00001
	22	Mor NOAEL	<0.00001	<0.00001
Copper	4.05	Rep/Gro/Mor NOAEL	1.00	1.00
	18.5	Rep/Gro NOAEL	1.00	0.61
	20.8	Rep/Gro NOAEL	1.00	0.27
	22	Mor NOAEL	1.00	0.15
	28.7	Rep/Gro LOAEL	0.91	0.002
	42	Mor LOAEL	0.34	<0.00001
	68.4	Mor LOAEL	0.006	<0.00001

Notes:

EBV = Ecological Benchmark Value

mg dw/kg bw-d = milligrams of dry weight per kilogram of body weight per day

LOAEL = Lowest Observed Adverse Effects Level

NOAEL = No Observed Adverse Effects Level

Rep/Gro = Reproductive/Growth

Mor = Mortality

na = not available

Acceptable risk level (ARL)[OAR 340-122-115(6)] for populations of ecological receptors is a 10% or less chance that 20% or more of the total local population would receive an exposure greater than the EBV.

Values that exceed 10% are bold-italicized.

Refer to Appendix F for all risk calculation worksheets

\* = although the actual probability was 0 due to mathematical circumstances of the binomial distribution function, the probability is better represented as 1.

## FIGURES



**Legend**

■ Riverbank Sampling Locations

Discrete samples indicated by: ⊙

Composite samples indicated by: +

SIUF OU Boundaries (approx.)

■ OU1

■ OU2

■ OU4

Outfalls/Storm Water Pipes

▲ Outfall - abandoned

■ Outfall - active

◆ Outfall - inactive

⊕ Storm water pipe (end) - abandoned July 2006

Notes:

- OU = Operable Unit; ERA = Ecological risk assessment

- Composite samples were created by combining discrete samples - but these samples are presented as separate points on this figure, so as to be able to present results for those samples.

- Aerial photography - 2009

- Boundaries and sampling locations are approximate; based on latest information provided by Ash Creek Associates.

0

100

200

Feet

Swan Island Upland Facility - Operable Unit 2

Willamette River

SWAN ISLAND UPLAND FACILITY  
OU2 - FINAL LEVEL II SCREENING ERA

FIGURE 1-1  
SITE OVERVIEW AND  
SAMPLING LOCATIONS

PRJ: 007-013	FEB 24, 2012	
REV: 0	BY: RCR	CHK: MCL
FORMATION ENVIRONMENTAL		



**FORMATION**  
ENVIRONMENTAL